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ScienceDirect

Procedia Technology 27 (2017) 35 – 36

Procedia Technology

Biosensors 2016

Polymer structures on surface acoustic wave biosensors

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Abstract

The influence of surface structuring on surface acoustic wave (SAW) biosensor signals has been investigated. Polymer structures on the sensor surfaces were applied by lithography or by self-assembling of polystyrene microparticles. In first experiments, structured and unstructured sensors led to similar results in a model affinity assay using streptavidin and biotinylated protein. On the other hand, structuring had a strong effect on SAW sensor signals obtained by protein adsorption on parylene C coated sensors. Depending on the protein, both decreased (albumin, streptavidin) and increased (fibrinogen) signals were observed with structured SAW sensors. Particularly the latter could contribute to facilitated blood analysis in the future.
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Peer-review under responsibility of the organizing committee of Biosensors 2016

Keywords: surface modification; microstructures; polymers; maskless lithography; colloid crystals; surface acoustic wave

1. Introduction

Surface structuring enhances the total surface area and changes the wettability of the surface. These and other effects influence biosensor signals in a variety of ways [1]. In this work, polymer structures obtained by lithography and by self-assembled polymer particles were applied on SAW biosensors [2]. The influence of the structures on the SAW biosensor signal responses in affinity assays and protein adsorption experiments was investigated.

2. Methods

Microstructures were fabricated by maskless projection lithography [3] or by self-assembling of polystyrene particles forming colloid crystals. The SAW biosensor measurement setup has recently been described in detail [4].

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Peer-review under responsibility of the organizing committee of Biosensors 2016
doi:10.1016/j.protcy.2017.04.017

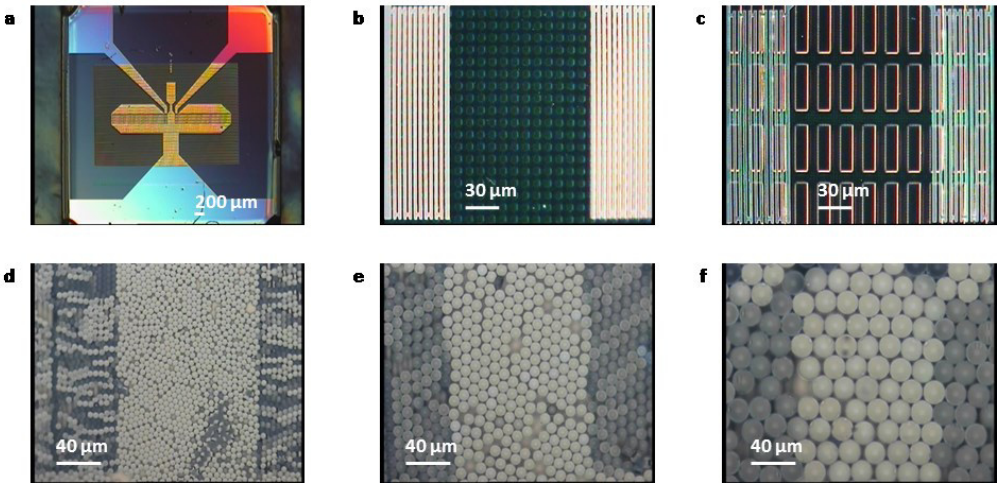

Fig. 1. SAW device surfaces structured by lithography, see (a)-(c), and with polystyrene microparticles, see (d)-(f); (a) lithographically structured area; (b) 5 x 5 x 0.85 µm (L x W x H) columns; (c) 37.5 x 10 x 0.85 µm (L x W x H) columns; particle size (d) 5 µm; (e) 10 µm; (f) 20 µm.

3. Results and discussion

Structuring with maskless projection lithography principally allows the testing of a high variety of structural shapes (Fig. 1 (a)-(c)). However, the height of the structures and, therefore, the changes in area increase and surface wettability was limited here due to the limited thickness of the resist. Therefore, after coating with parylene C (poly(2-chloro-p-xylylene)), similar water contact angles were obtained with structured and unstructured surfaces. Furthermore, the lithographic structures were not stable regarding surface modification steps required for biosensing experiments. Structures based on polystyrene microparticles forming colloid crystals (Fig. 1 (d)-(f)), on the other hand, could further be modified after parylene C coating, as shown by successful covalent coupling of a protein-repellent hydrogel providing biotin groups (water contact angles < 20°). Immobilization of streptavidin, BSA (bovine serum albumin) blocking and applying biotinylated BSA samples resulted in similar SAW biosensor signal responses with structured and unstructured surfaces, i.e., the increased surface area has not yet shown a beneficial effect. The development of an improved surface modification protocol to cope with this problem is under way.

After coating the particle-structured surfaces with parylene C, water contact angles increased from 90° (unstructured surfaces) to approx. 110° (particle structures). Adsorption of streptavidin resulted in reduced SAW biosensor frequency shifts on structured sensors. Adsorption of human serum albumin resulted in similar frequency shifts on surfaces with no structures and with 5 µm structures, whereas adsorption of fibrinogen resulted in a threefold increased frequency shift with 5 µm structures compared to unstructured surfaces. Using 10 µm and 20 µm structures, adsorption of all proteins resulted in significantly reduced frequency shifts. The special results obtained with fibrinogen and 5 µm structures are attributed to conformational changes after adsorption, as observed earlier [5]. The exploitation of this effect for blood analysis is currently under investigation.

References

[1] Bruzzone AAG, Costa HL, Lonardo PM, Lucca DA. Advances in engineered surfaces for functional performance. CIRP Ann Manuf Technol 2008; 57:750-69.
[2] Länge K, Rapp BE, Rapp M. Surface acoustic wave biosensors: a review. Anal Bioanal Chem 2008; 391:1509-19.
[3] Waldbaur A, Carneiro B, Hettich P, Wilhelm, E, Rapp BE. Computer-aided microfluidics (CAMF): from digital 3D-CAD models to physical structures within a day. Microfluid Nanofluid 2013; 15:625-35.
[4] Hohmann S, Kögel S, Brunner Y, Schmieg B, Ewald C, Kirschhöfer F, Brenner-Weiß G, Länge K. Surface acoustic wave (SAW) resonators for monitoring conditioning film formation. Sensors 2015; 15:11873-88.
[5] Clarke ML, Wang J, Chen Z. Conformational changes of fibrinogen after adsorption. J Phys Chem B 2005; 109:22027-35.